ACCAP

Alaska Center for Climate Assessment and Policy

Welcome to the ACCAP'S Alaska Climate Webinar Series

Tuesday, July 23, 2013

Webinar Moderated by:

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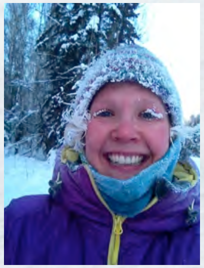

International Arctic Research Center

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Photo courtesy of Matt Druckenmiller

ACCAP

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Climate Change and Boreal Forest Fires: What does the future hold?

Mike Flannigan

University of Alberta

Climate Change and Boreal Forest Fires: What does the future hold?

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WESTERN PARTNERSHIP FOR WILDLAND FIRE SCIENCE

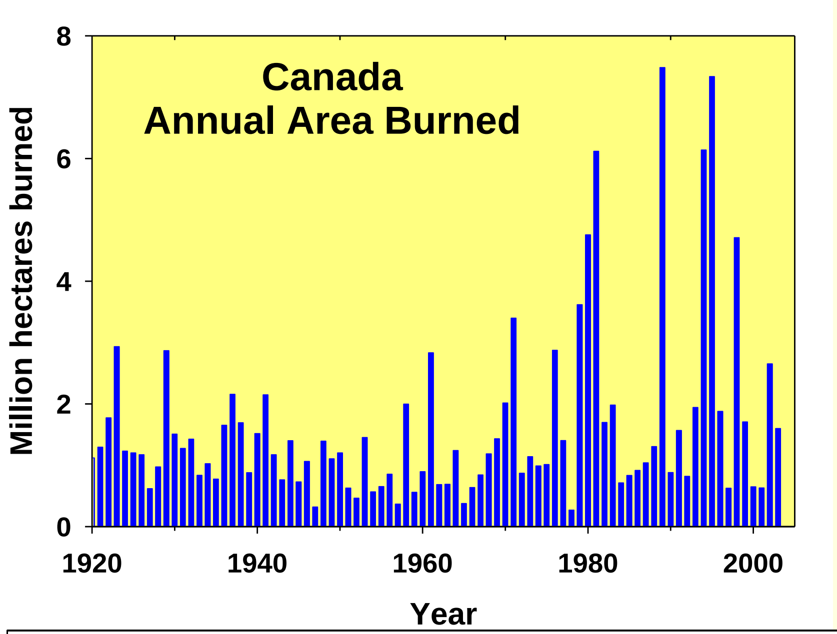
Outline

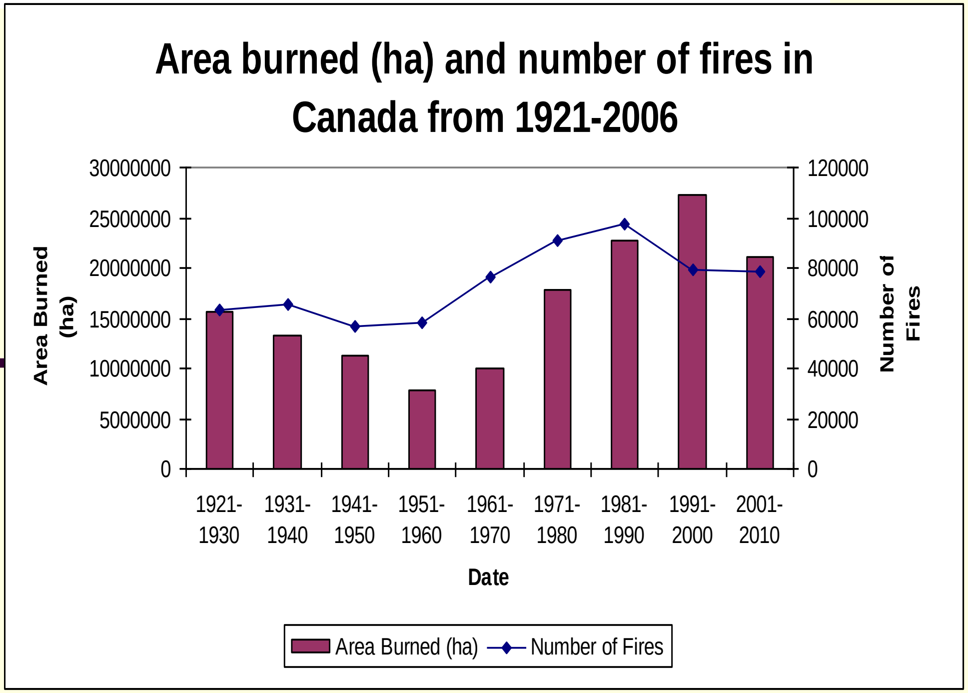
- Fire background
- Climate change and impacts of climate change on fire activity
- Options
- Peatfire – a wildcard

Fire Impacts

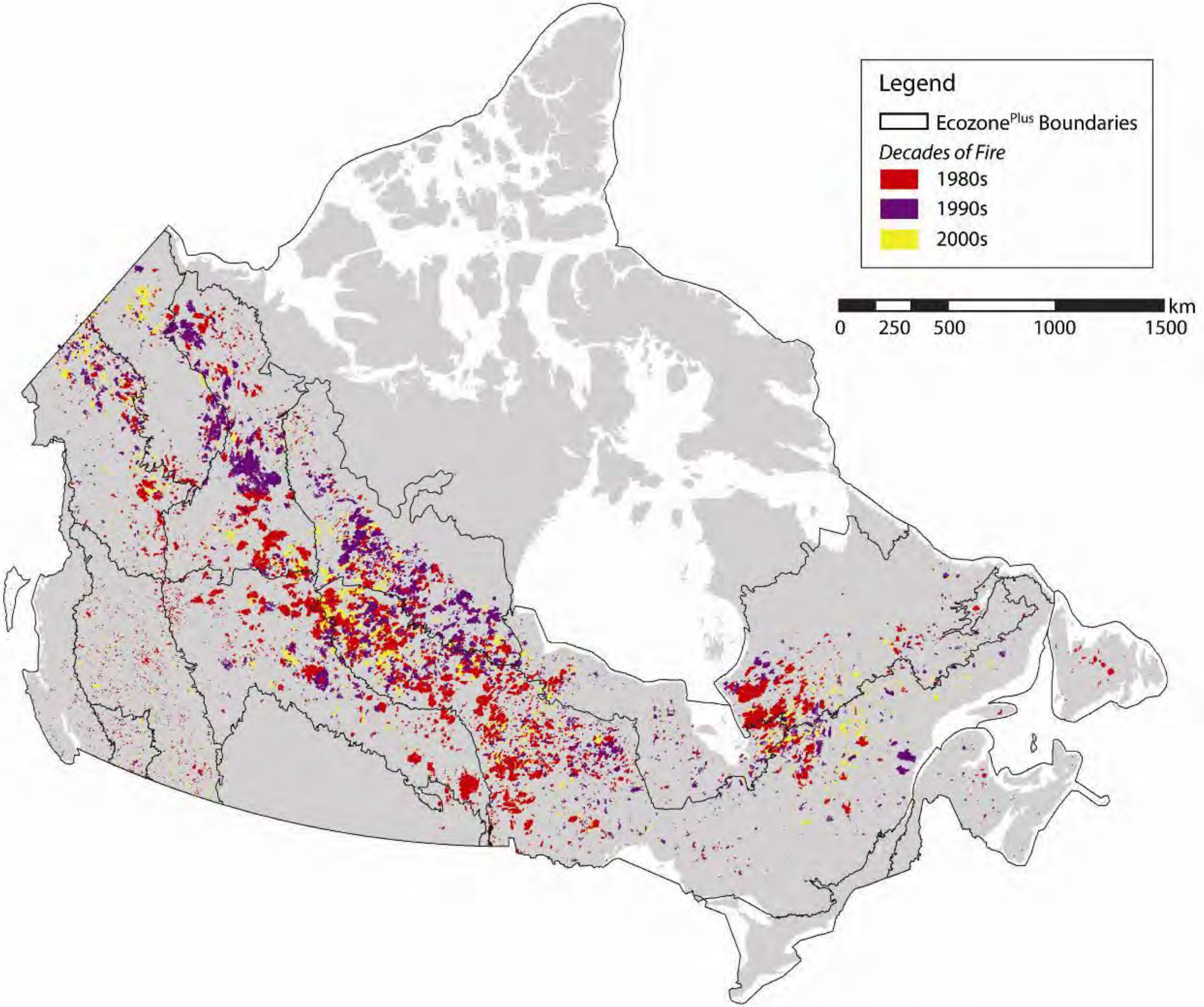
- Location, location location
- Australia 2009,2013, Russia 2010 and southern USA 2011
- Waldo Creek Fire & High Park Fire 2012, Black Forest Fire, Yarnell Fire 2013
- Smoke fatalities estimated at 330,000 per year

Canadian Fire Statistics



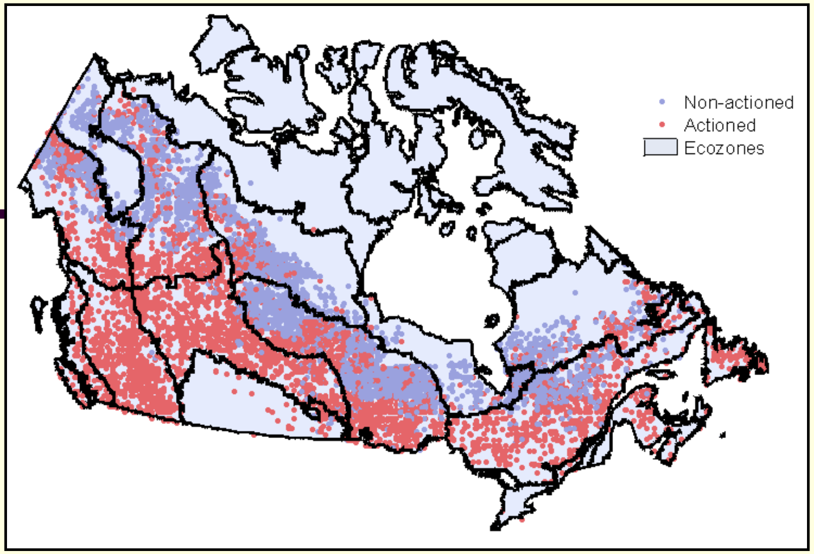


- Incomplete prior to 1970
- Currently - average of 8000 fires a year burn 2 million ha – 1 million ha in the early 1970s
- Primarily crown fires
- Area burned is highly episodic
  - 0.4 to 7.6 million ha
- Lightning fires
  - 35% of total fires
  - represent 85% of area burned
- Fire size
  - 3% of fires are >200 ha
  - represent 97% of area burned



The distribution of large fires across Canada, 1980s to 2000s.
Each colour represents the fires in the corresponding decade (1980s to 2000s).
The 2000 decade includes only data from 2000-2007

Fire Issues



- An average of $800 million spent by fire management agencies in Canada a year on direct fire fighting costs; these costs are rising.
- Health and safety – evacuations – smoke
- Property and timber losses due to fire
- Balancing the positive and negative aspects of fire
- Traditional approaches to fire suppression (e.g., crews, air tankers) may be reaching their limit of economic and physical effectiveness

Fire Ecology

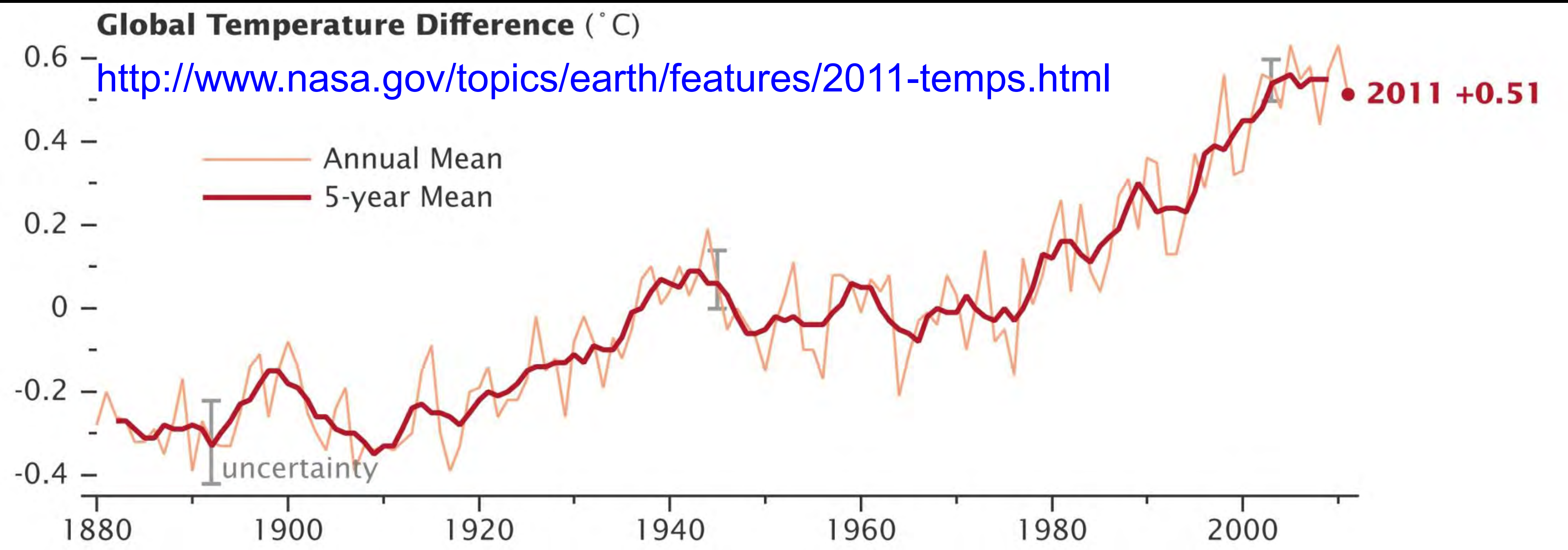
- Boreal forests survive and even thrive in semi-regular high intensity fires (stand renewal)
- Removes competition
- Prepares seedbed
- Survival strategies - Cone serotiny, vegetative reproduction and bark thickness
- Standard climax succession models not applicable to much of the boreal - WYSIWYG applies
- Disturbances like fire help shape the composition and biodiversity of our forests

Forest Fires – 4 Key Factors

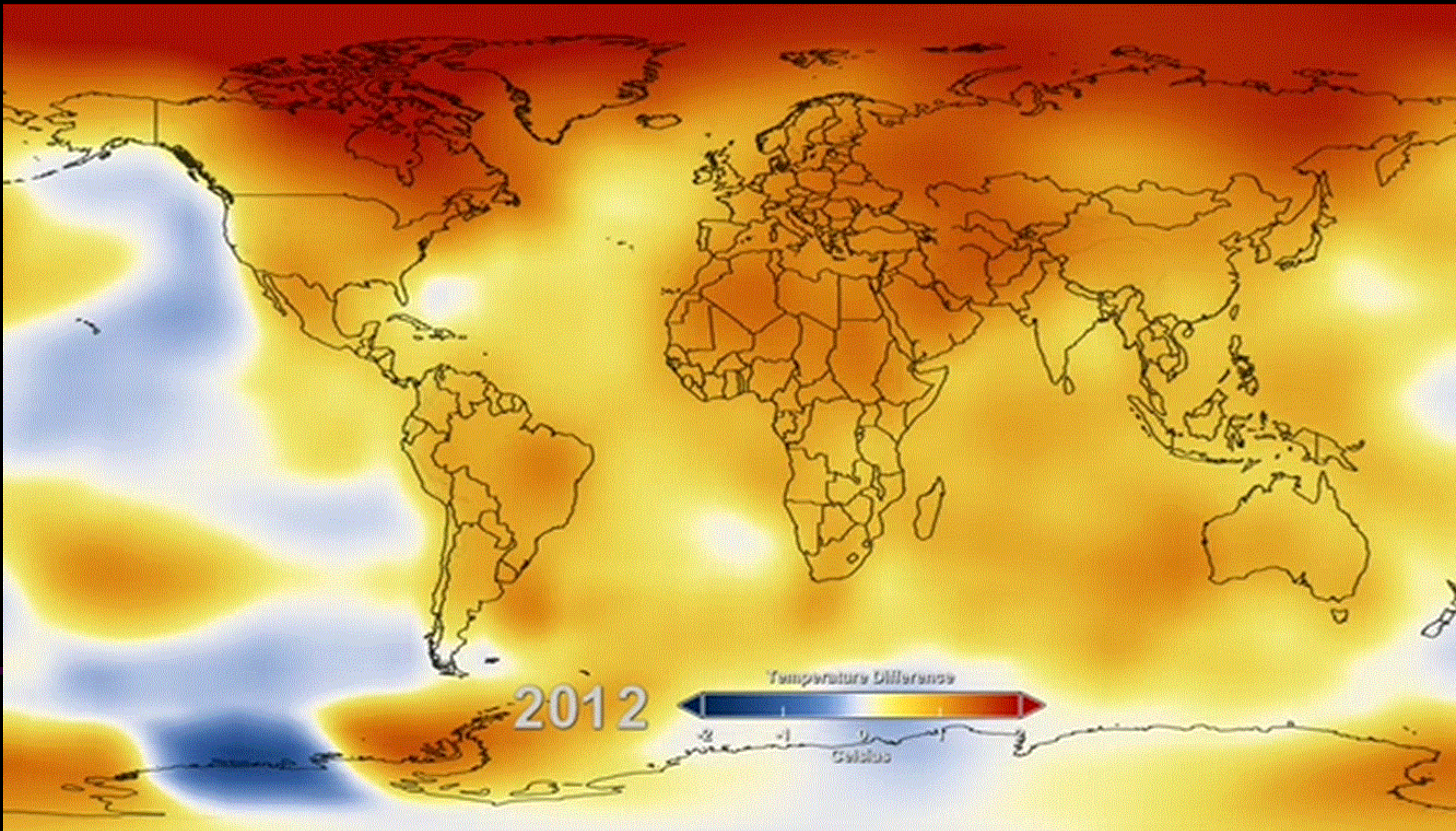
- Fuel - loading, moisture, structure etc.
- Ignition - human and lightning
- Weather - temperature, precipitation atmospheric moisture and wind; sunshine, upper atmospheric conditions (blocking ridges)
- Humans - land use, fragmentation, fire management etc.

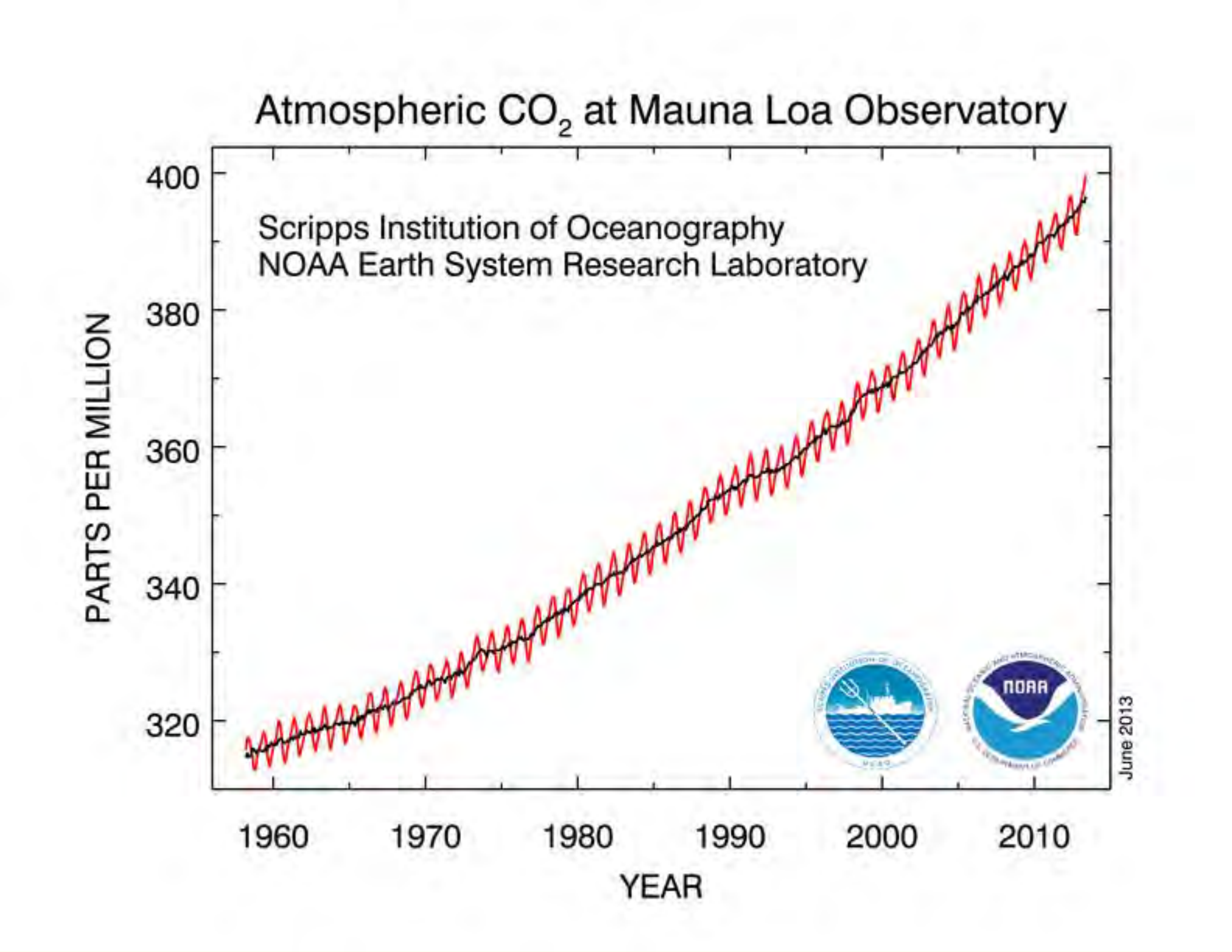
Fires -Key Factors Part 2

- Weather is a component in all 3 natural factors – fuel, ignitions (Lightning) -.
- Options -Weather – we can't control; only options are fuel and human-caused fire ignitions
- Prevention – education, restricted fire zones, reduce or eliminate industrial activity during periods of high fire danger, enforcement
- Fuel – modifications – fuel break, reduce fuel load or change fuel type either at the landscape level (strategically) or areas of high value (e.g., communities)



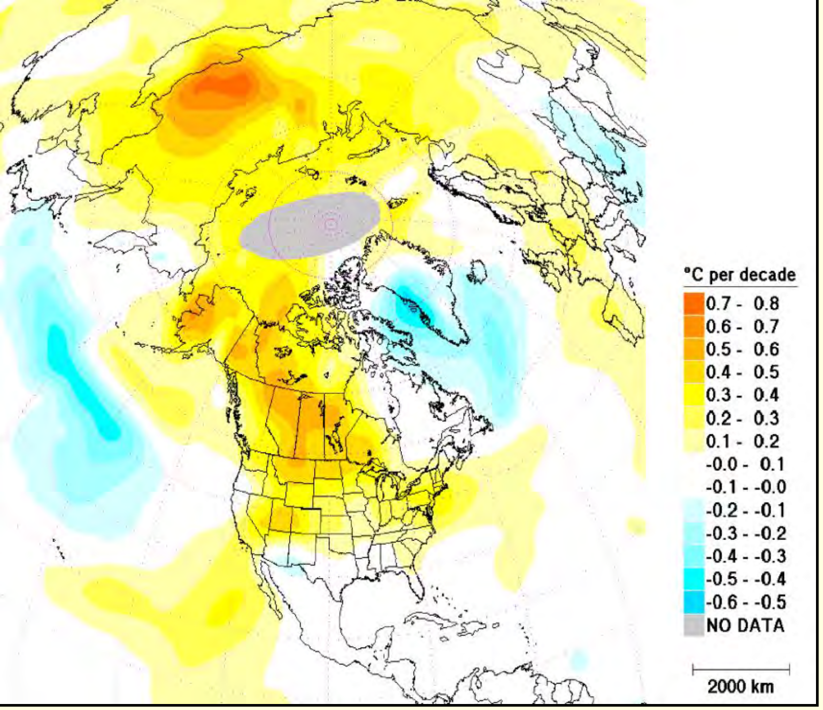
http://www.nasa.gov/topics/earth/features/2011-temps.html


2012
Temperature Difference
-2
-1
0
1
2
Celsius

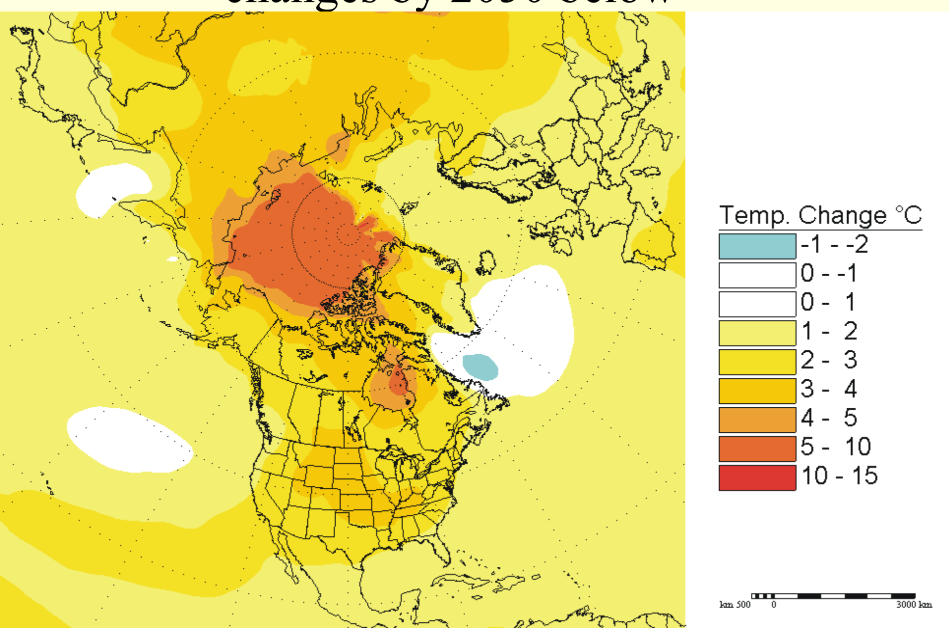


http://www.esrl.noaa.gov/gmd/ccgg/trends

Climate Change Projections

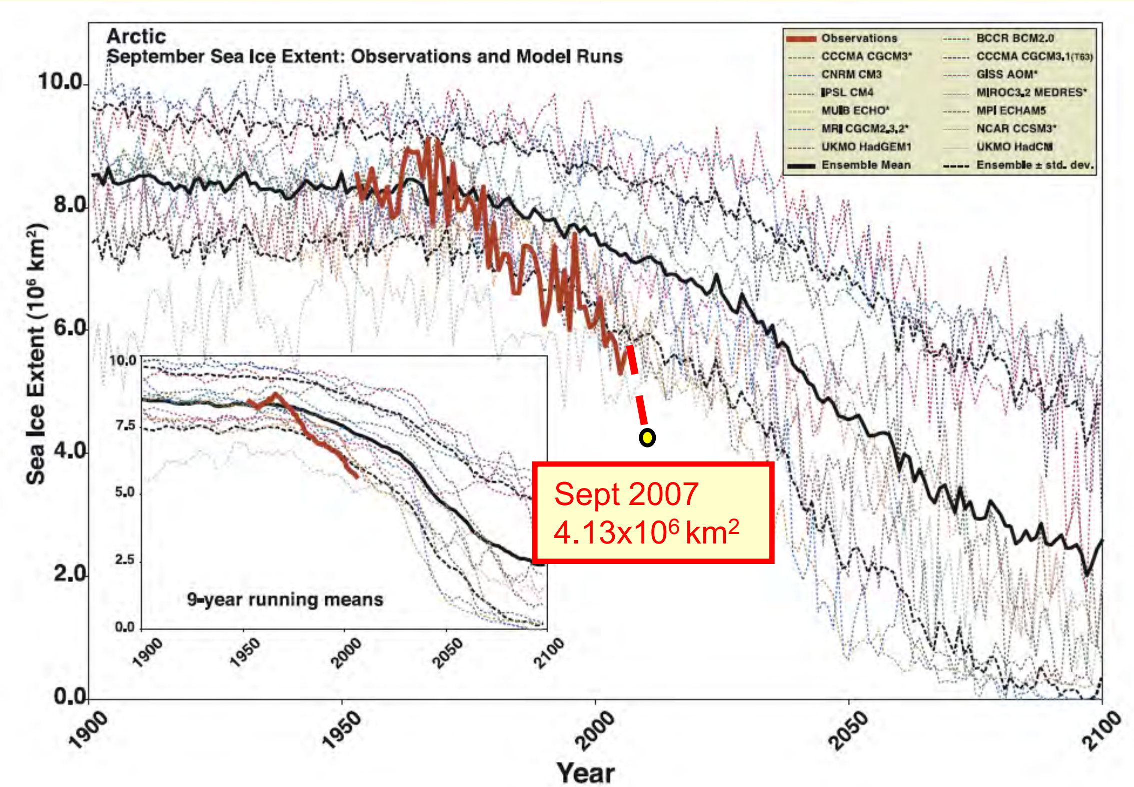


Observations above – temperature changes by 2050 below

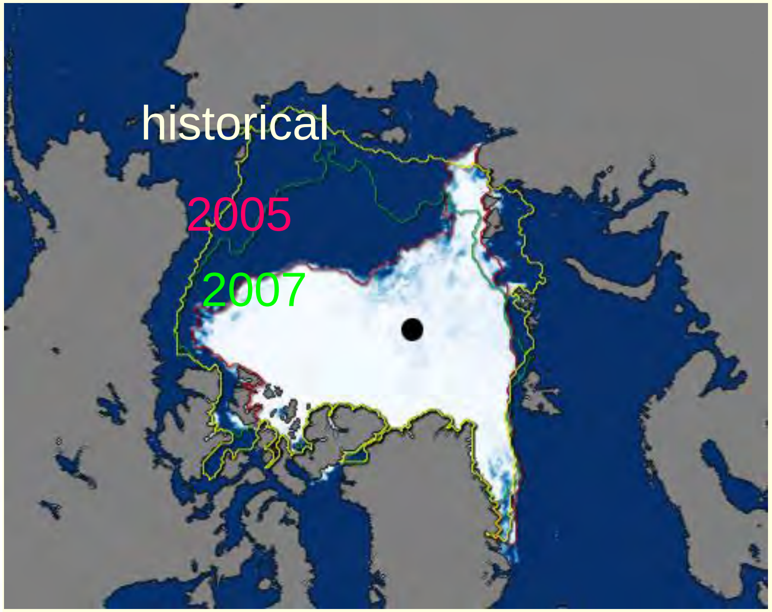


- GCMs project 1.4 – 5.8^0 C increase in global mean temperature by 2100
- Greatest increases will be at high latitudes, over land and winter/spring
- Projected increases in extreme weather(e.g., heat waves, drought, floods, wind storms and ice storms) – weakening jet stream
- Observed increases across west-central Canada and Siberia over past 40 years

Polar Ice Cap – Rapidly melting

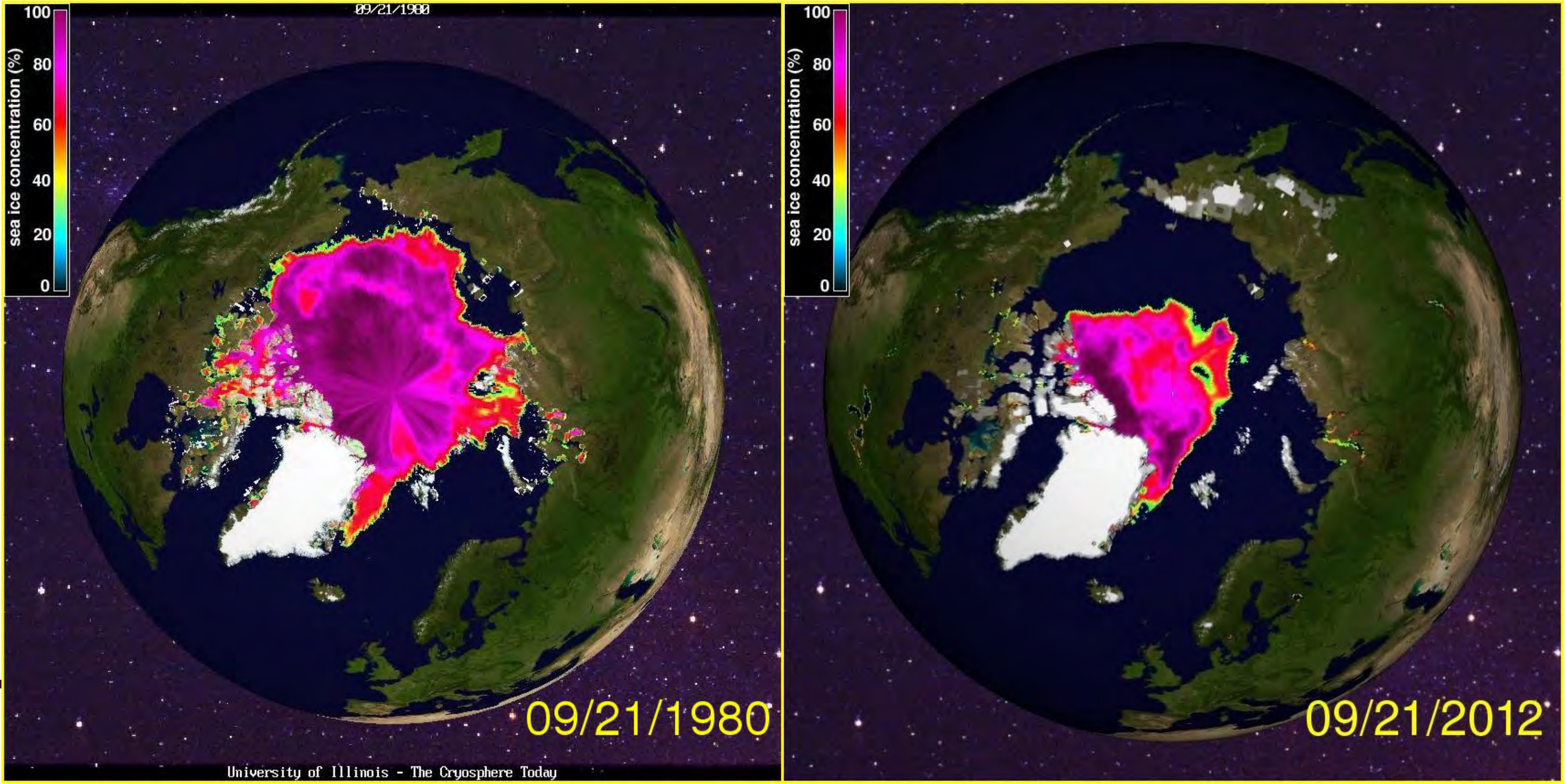


Stroeve et al. 2007, Geophys. Res. Lett. 34, L09501



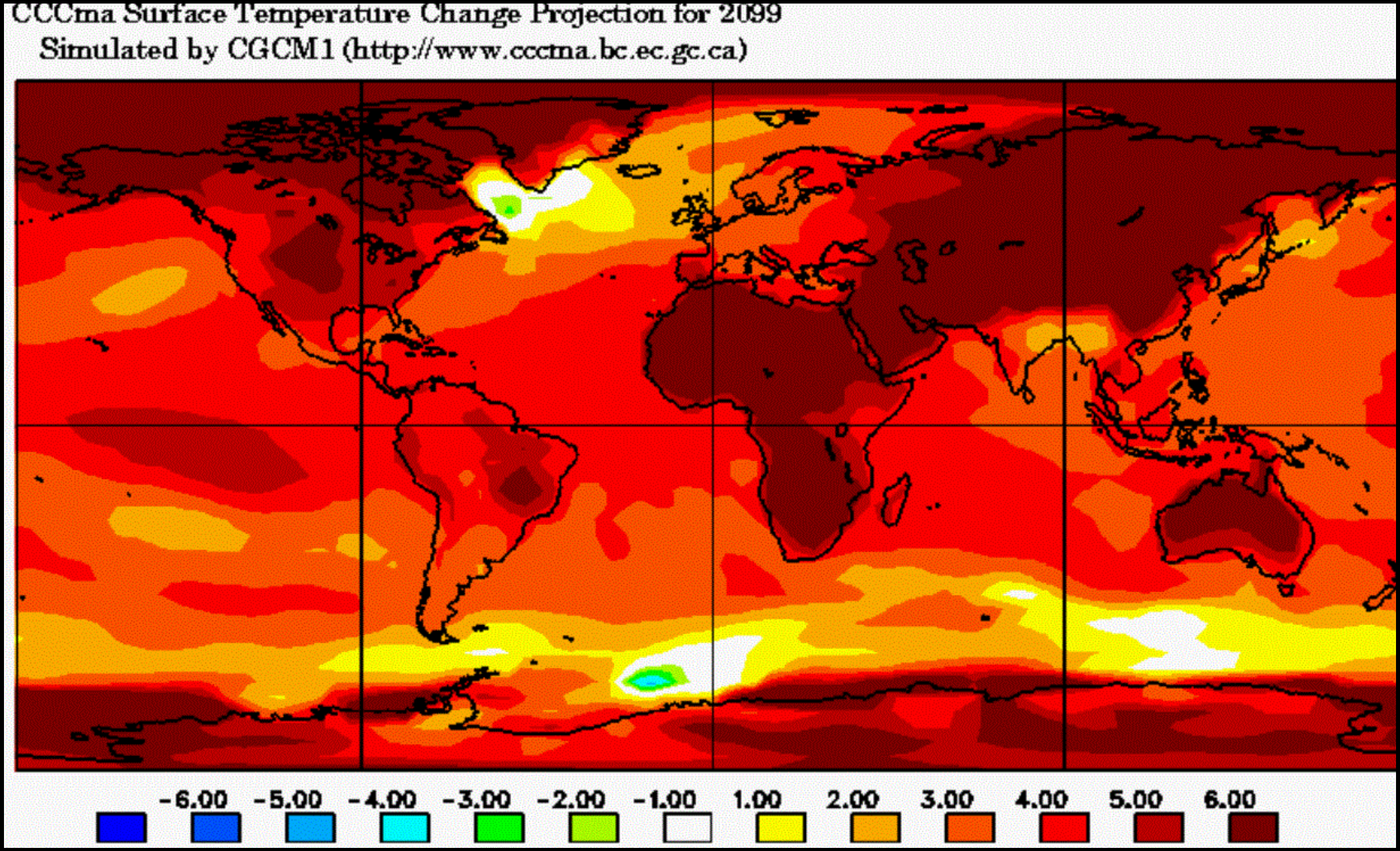
Minimum annual extent of Arctic sea ice is decreasing faster than all model projections

Polar Ice Cap – Rapidly melting

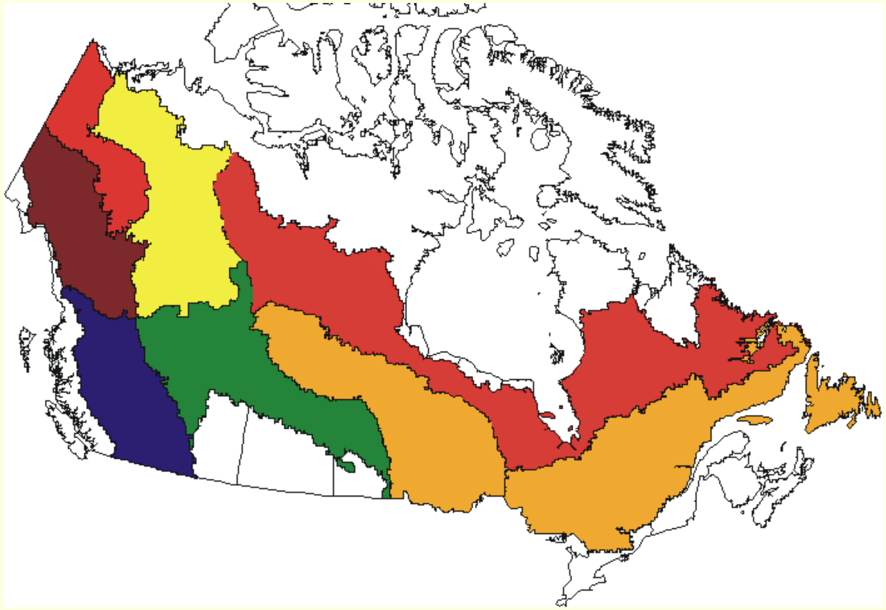


Variability

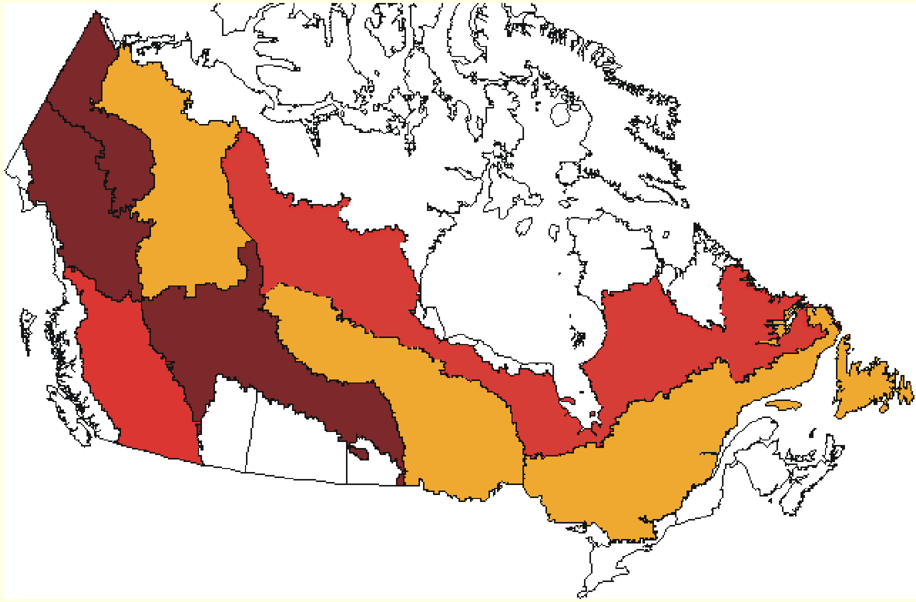
- Variability – a real problem for fire with respect to extremes – a few critical days are responsible for most of the area burned
- Fire then flood
- Wind – average unchanged but more variable; more extreme wind events


CCCma Surface Temperature Change Projection for 2099
Simulated by CGCM1 (http://www.cccma.bc.ec.gc.ca)
-6.00 -5.00 -4.00 -3.00 -2.00 -1.00 1.00 2.00 3.00 4.00 5.00 6.00

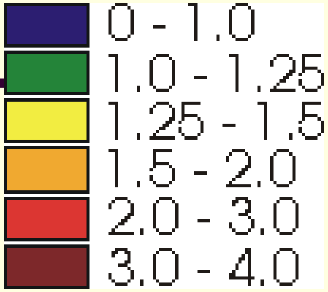
Area Burned Projections



Canadian – $3xCO_2$



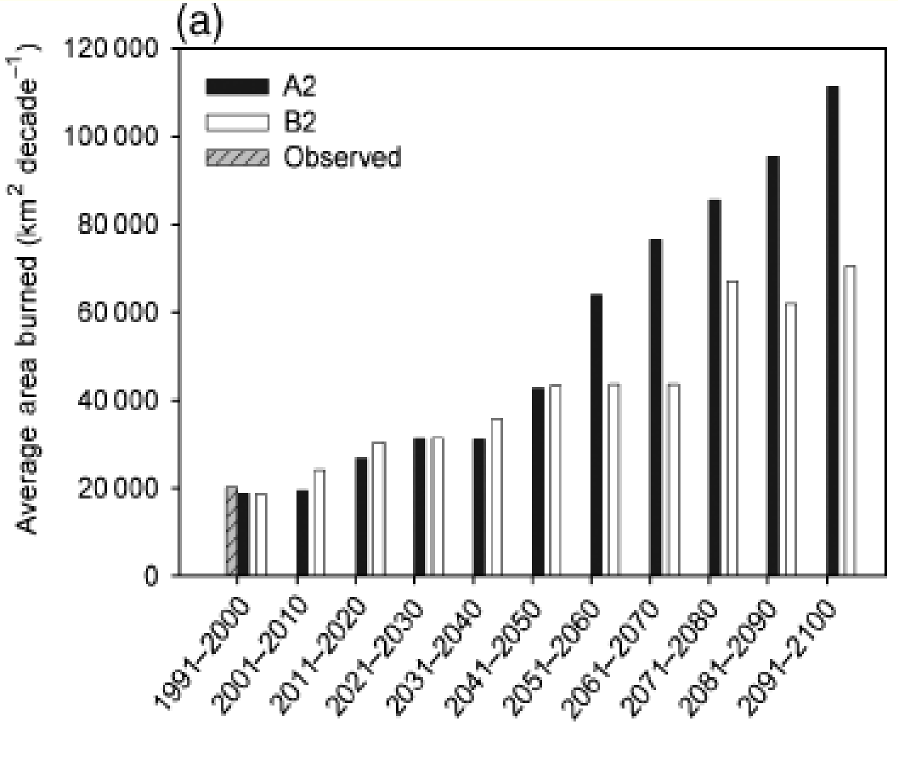
Hadley –$3xCO_2$



Projections of area burned based on weather/fire danger relationships suggest a 75-120% increase in area burned by the end of this century according to the Canadian and Hadley models respectively

Flannigan, M.D., Logan, K.A., Amiro, B.D., Skinner, W.R. and Stocks, B.J. 2005. Future area burned in Canada. Climatic Change. 72:1-16

Area Burned – Alaska W. Canada

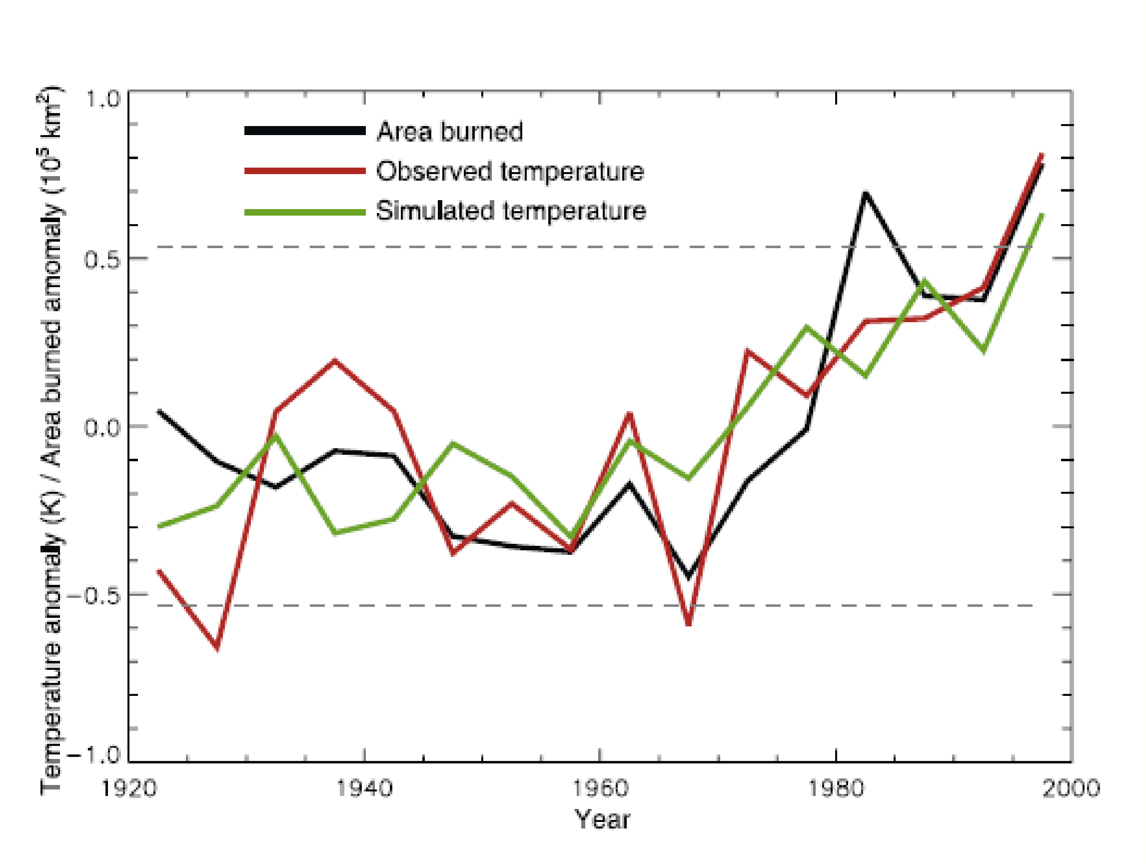


- Predicted mean annual area burned (km^2/yr) per decade for Alaska and western Canada driven (by the NCEP model development datasets(1990–2005) and the CGCM2 A2 and B2 climate scenarios (2006–2100).

Balshi, M et al. 2008. Modeling historical and future area burned of western boreal North America using a Multivariate Adaptive Regression Splines (MARS) approach. Global Change Biology. DOI: 10.1111/j.1365-2486.2008.01679.x.

Trend Observations

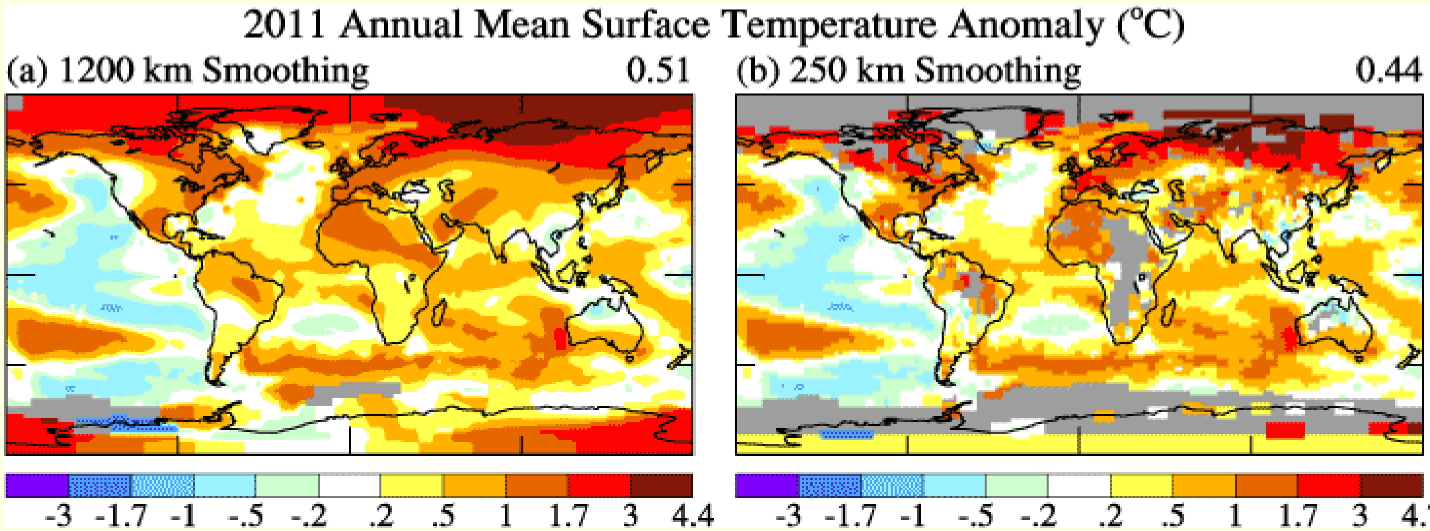
- Is area burned correlated with increasing temperature?
- Is this caused by anthropogenic effects?



Gillett, N.P.et al. 2004. Detecting the effect of climate change on Canadian forest fires. Geophysical Research Letters. 31(18), L18211, doi:10.1029/2004GL020876.

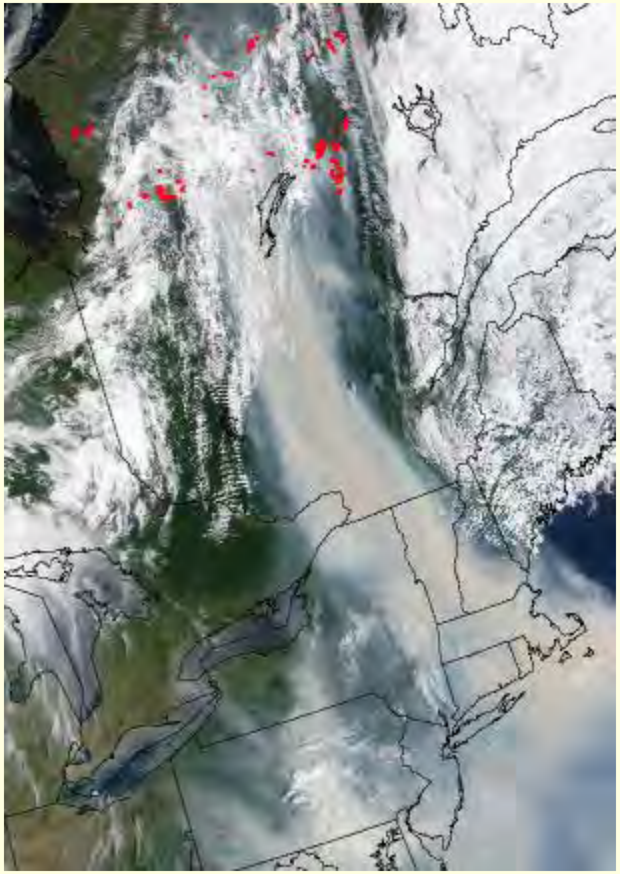
Fire & Temperature

- Key variable in fire activity for 3 reasons
- First, the amount of moisture the atmosphere can hold is highly sensitive to temperature. This drives fuel moisture; if temperature increases then significant increases in precipitation are needed to compensate Approx. 10% increase.in prec. for every degree of warming
- Second, temperature has a strong positive correlation with lightning…the warmer it is the more lightning we have.
- Third, the warmer it is the longer the fire season; particularly important at high northern latitudes.



Parisien, M-A., Parks, S.A., Krawchuk, M.A., Flannigan, M.D., Bowman, L.M., and Moritz, M.A. (2011). Scale-dependent controls on the area burned in the boreal forest of Canada, 1980-2005. *Ecological Applications* 21: 789-805.

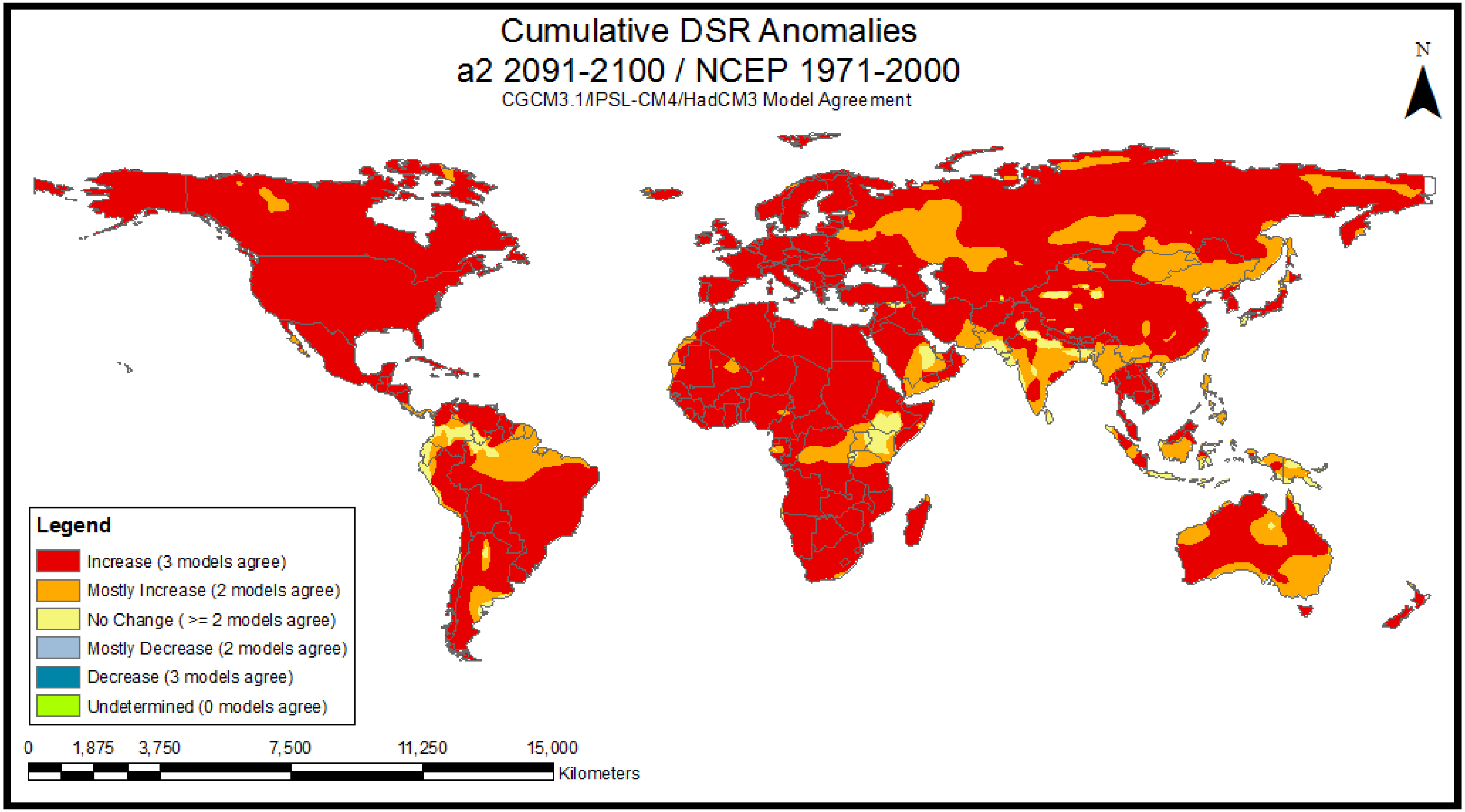
Future Fire Regimes –Data & Methods 1

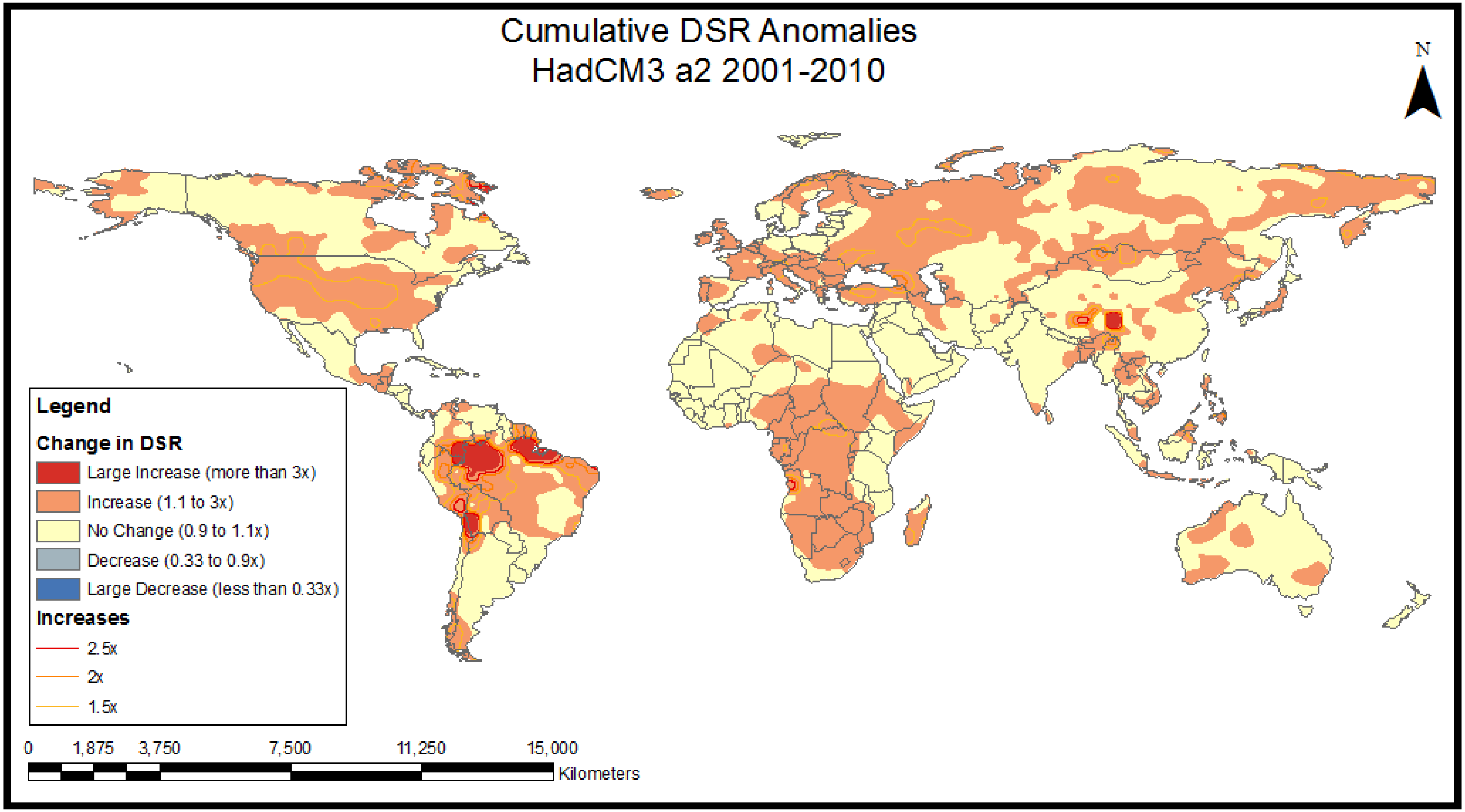


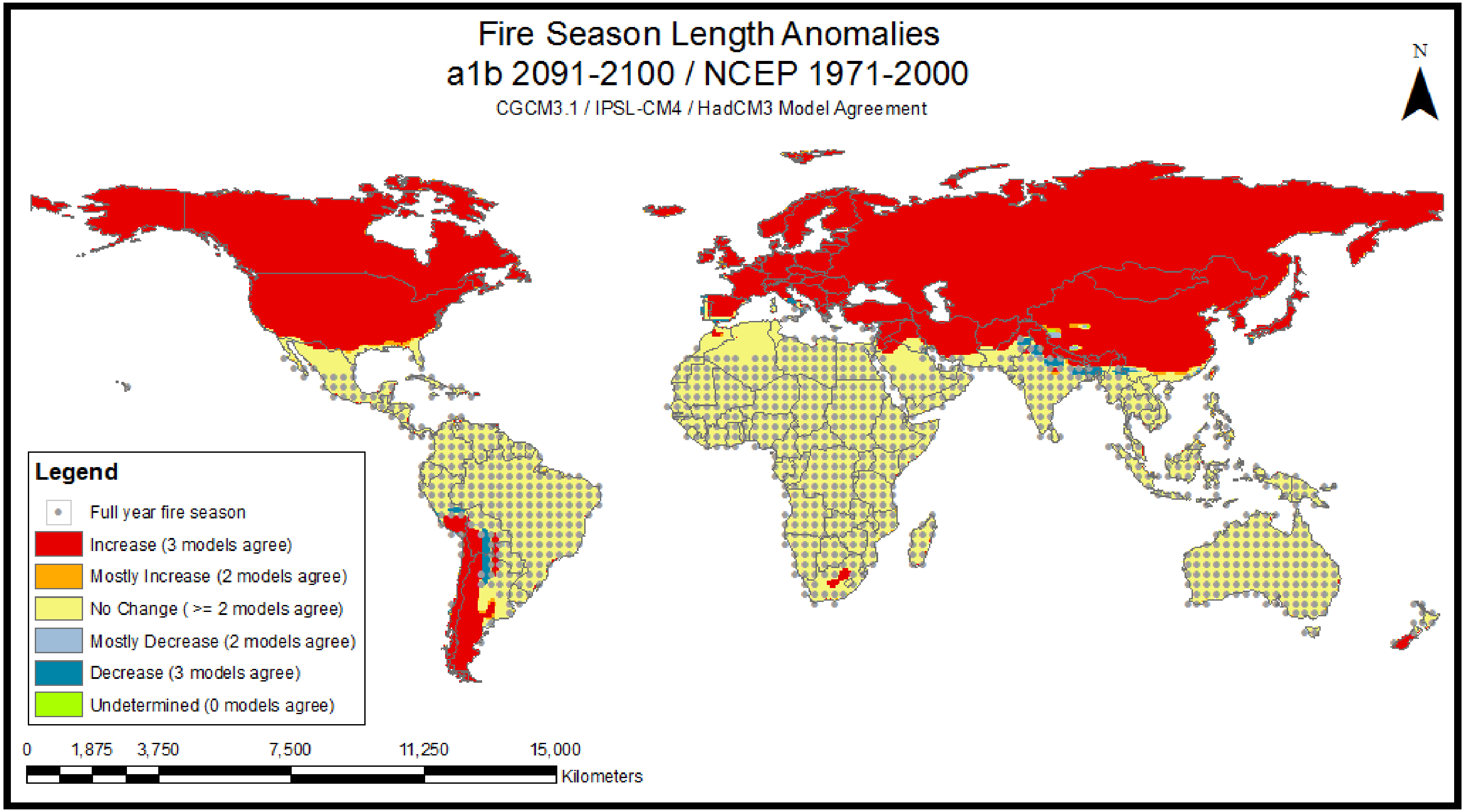
- Used NCEP reanalysis data to calculate the Canadian Fire Weather Index System components including DSR for the world 1971-2000.
- The Canadian FWI System is used across Canada and in many parts of the world.
- Used a cumulative DSR to determine the severity of the fire season. The DSR is function of the FWI to provide a measure of the control difficulty to suppress a fire.

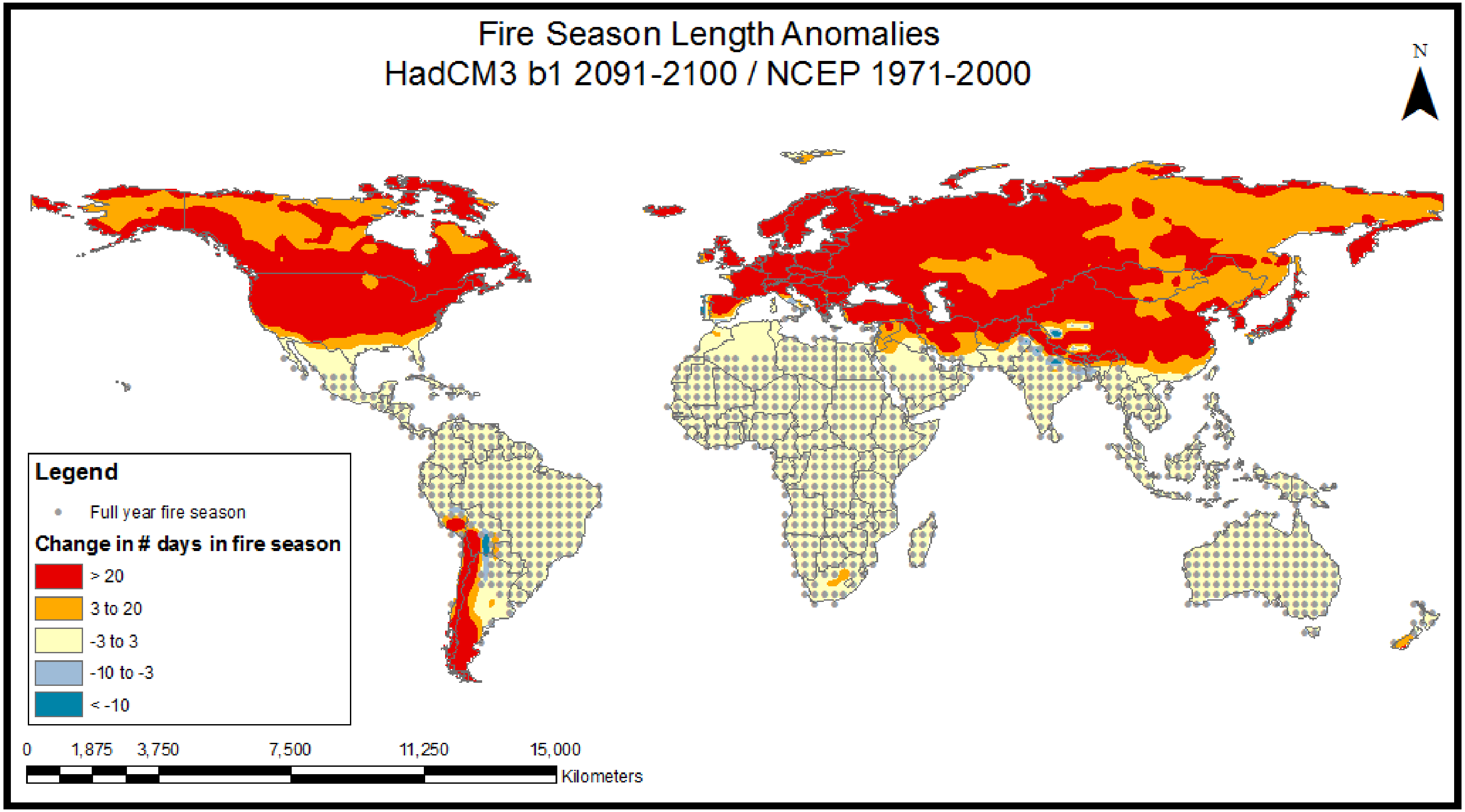
Future Fire Regimes – Data & Methods 2

- Three emission scenarios –A1B, A2, B1 from three GCMS – Canadian, Hadley and French IPSL. Superimposed anomalies from a future decade/baseline to the NCEP data - calculated the FWI System components with the revised data
- Calculated compared the cumulative DSR and fire season length – present and future.


Cumulative DSR Anomalies
a2 2091-2100 / NCEP 1971-2000
CGCM3.1/IPSL-CM4/HadCM3 Model Agreement
N
Legend
Increase (3 models agree)
Mostly Increase (2 models agree)
No Change (>= 2 models agree)
Mostly Decrease (2 models agree)
Decrease (3 models agree)
Undetermined (0 models agree)
0
1,875
3,750
7,500
11,250
15,000
Kilometers


Cumulative DSR Anomalies
HadCM3 a2 2001-2010
N
Legend
Change in DSR
Large Increase (more than 3x)
Increase (1.1 to 3x)
No Change (0.9 to 1.1x)
Decrease (0.33 to 0.9x)
Large Decrease (less than 0.33x)
Increases
2.5x
2x
1.5x
0
1,875
3,750
7,500
11,250
15,000
Kilometers


Fire Season Length Anomalies
a1b 2091-2100 / NCEP 1971-2000
CGCM3.1 / IPSL-CM4 / HadCM3 Model Agreement
N
Legend
Full year fire season
Increase (3 models agree)
Mostly Increase (2 models agree)
No Change (>= 2 models agree)
Mostly Decrease (2 models agree)
Decrease (3 models agree)
Undetermined (0 models agree)
0 1,875 3,750 7,500 11,250 15,000
Kilometers


Fire Season Length Anomalies
HadCM3 b1 2091-2100 / NCEP 1971-2000
N
Legend
Full year fire season
Change in # days in fire season
> 20
3 to 20
-3 to 3
-10 to -3
< -10
0
1,875
3,750
7,500
11,250
15,000
Kilometers

Future Fire

- Changes in climate (including warmer temperatures, changes in precipitation, atmospheric moisture, wind, and cloudiness) affect wildfires
- Direct, indirect, and interactive effects of weather/climate, fuels, and people will determine future fire activity

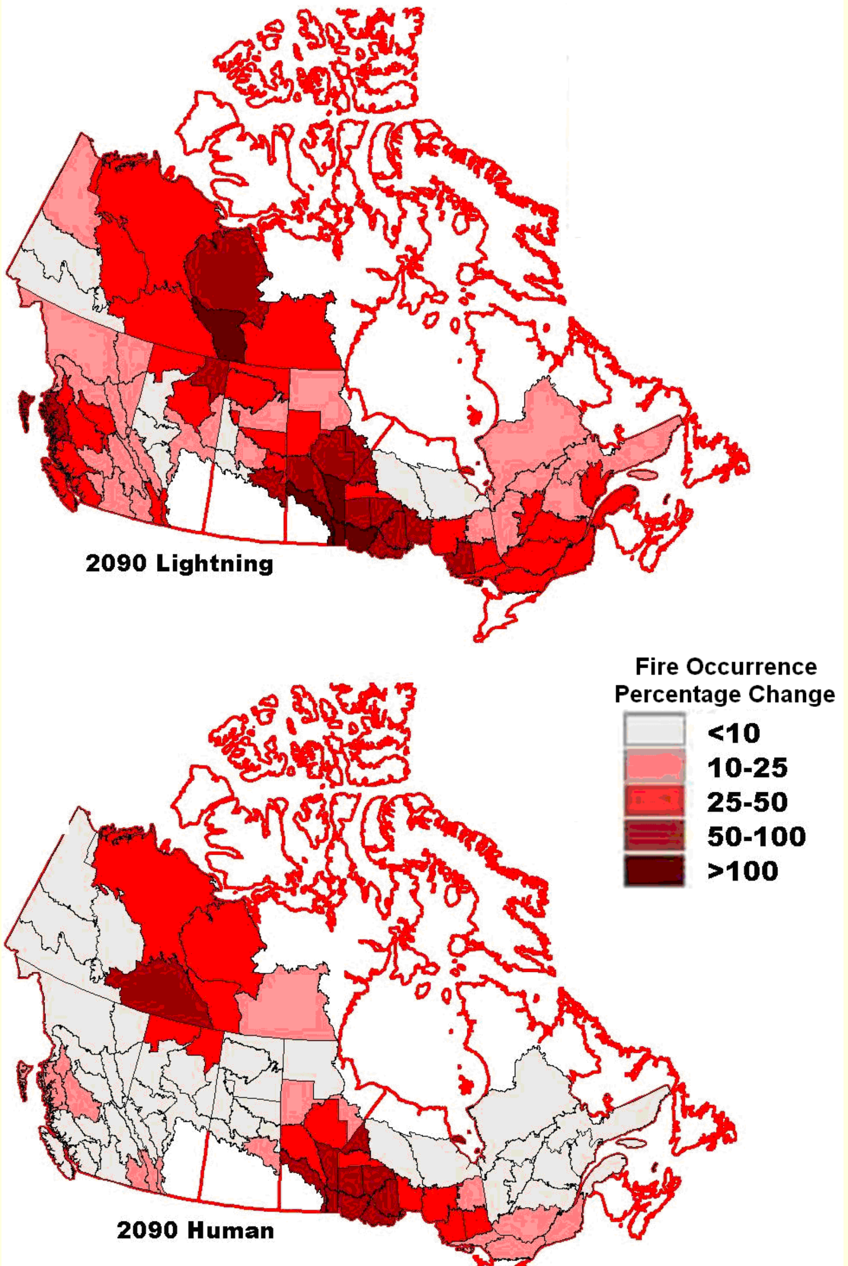
  Area burned

  Fire occurrence

  Fire season

  Fire intensity

  Fire severity



Relative change (percentage increase) in fire occurrence between future and baseline scenarios for the Canadian Climate Centre GCM. Relative change is given as the percentage increase in number of fires predicted by the GCM (future scenario minus baseline scenario) divided by the total number of fires in the baseline scenario (i.e., (N2020-2040 – N1975-1995)/ N1975-1995); “no data” is shown in white.

Flannigan, M.D., Krawchuk, M.A., de Groot, W.J., Wotton, B.M. and Gowman, L.M. (2009). Implications of changing climate for global wildland fire. *International Journal of Wildland Fire*,18, 483-507.

Wotton, B.M., Nock, C.A. and Flannigan, M.D. (2010). Forest fire occurrence and climate change in Canada. *International Journal of Wildland Fire*,19,253-271.

Options and Adaptations

- Health and safety - through improved fire weather and fire behaviour systems. The Canadian Forest Fire Danger Rating System is used across Canada and in many parts of the world.
- Adaptation options for fire management agencies with respect to climate change altered fire regimes including community protection
- Firewise – FireSmart for homes and communities
- Treating fuels near communities – removing fuel, changing fuel type from conifer to deciduous, sprinklers
- More people living and working in the forest – risk will increase

Fire and Carbon

Fire plays a major role in carbon dynamics: it can determine the magnitude of net biome productivity

1) combustion: *direct loss*

2) decomposition of fire-killed vegetation

3) Change in vegetation type : *different sink potential when there is a change in vegetation type. Example forest stand renewal – young successional stands have potential to be greater sinks than mature stagnant forests*

The role of Peat

- 700 Pg carbon stored in the boreal forest ~30-35 % of the global terrestrial biosphere.. peat is a major component.

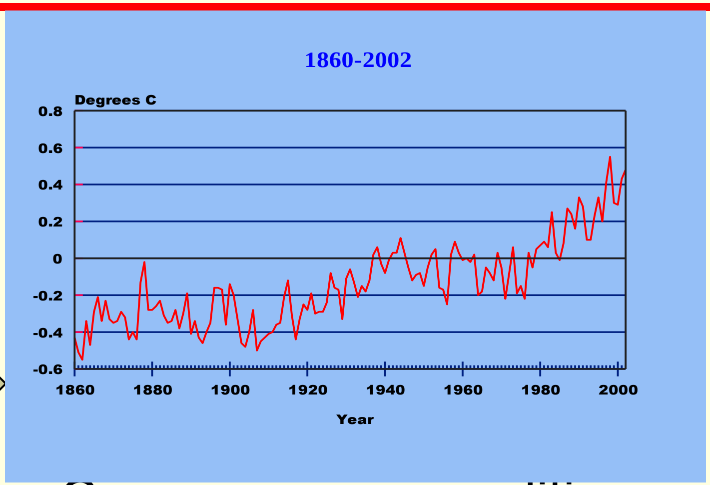
- Climate change will mean the thawing of permafrost, more droughts which suggest peat fires will be more common.

-Peat fires can release significant amounts of GHGs for example peat fires in Indonesia during 1997 released the equivalent of 20-50% of global fossil fuel emissions. Peat in the boreal dwarfs the amount of peat in tropical regions

-Difficult to extinguish; can burn through winter under the right conditions

Fire and Weather Feedbacks: potentially positive

Fossil Fuel emissions:
increase greenhouse gases



Cause warmer conditions

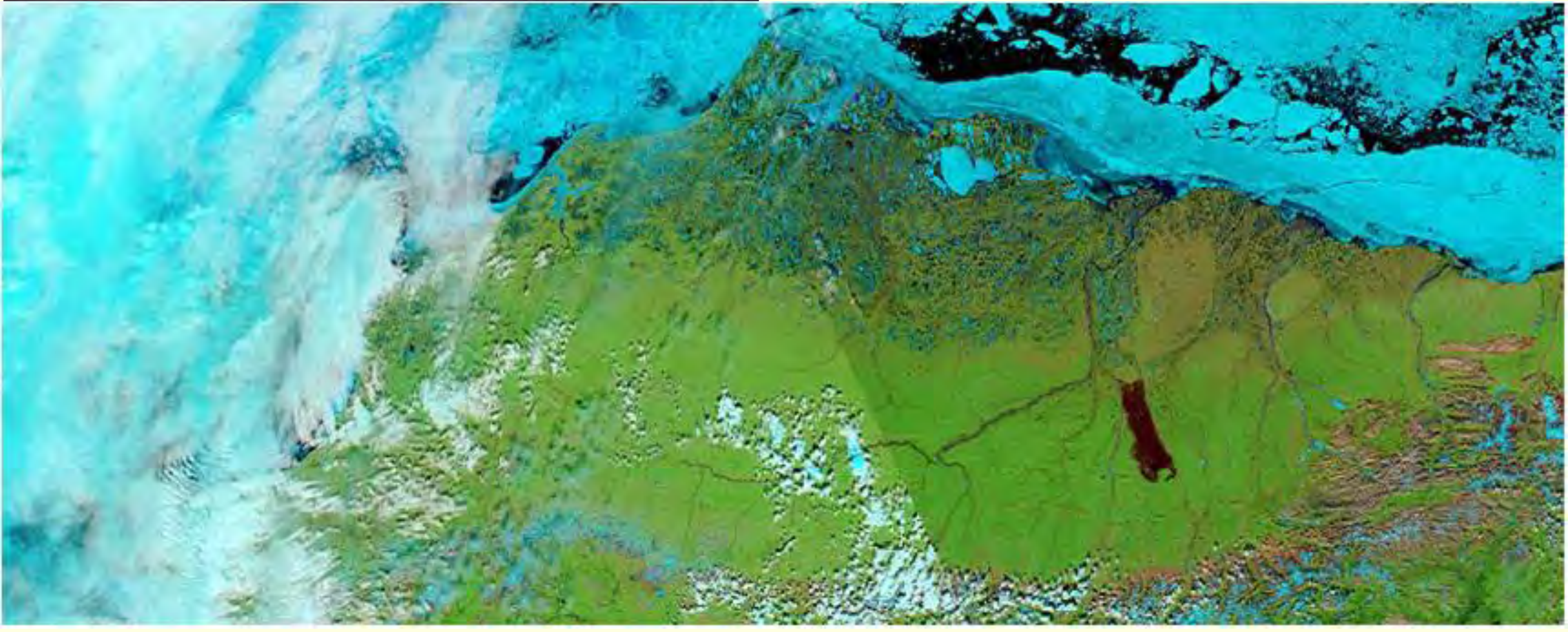
Weather becomes more
conducive to fire: more fire

Carbon released from more fire
enhances greenhouse gases further

Tundra fires

Anaktuvuk River Fire 2007

Photo credits: Alaska Fire Service



Summary

- Fire and weather are strongly linked

- A warmer world will have more extreme weather and more fire - Changes in forest fires may be the greatest early impact of climate change on forests

- Increased risk in the future due to increased fire activity – there will be more incidents like Slave Lake, Colorado Springs etc. in the future

- Traditional approaches to fire management will be even more challenging in the future

- There is the potential for a positive fire and GHGs

http://www.ualberta.ca/~flanniga/


STOP

WESTERN PARTNERSHIP FOR
WILDLAND FIRE SCIENCE

http://www.ualberta.ca/~wcwfs/